Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

AN ECOLOGIC STUDY OF THE FLORA OF MOUNTAINOUS NORTH CAROLINA.

JOHN W. HARSHBERGER.

(*Concluded from p. 258.*)

THE VEGETATION OF THE MOUNTAIN REGION.

THE characteristic features of the vegetation of this whole region are found in the broad-leaved species, of which it is largely composed, associated with deciduous and evergreen shrubs, while lianes stretch from tree to tree, and herbaceous plants grow beneath the dominant forest species, or clothe the natural meadows of the higher mountain summits and the alluvial bottoms of the principal mountain streams. The association of these plants in the forest is largely due to their relation to light, soil, and moisture.

Relation to light.—All trees require a certain intensity of light for photosynthesis. Hence weak light is injurious; otherwise there is no reason why the foliage in the interior of the crowns of the trees should not be as dense as near the periphery. Marked differences occur among the various species of trees with regard to the measure of light necessary, and though affected by soil and situation, these differences are sufficient to admit of classification into tolerant and intolerant species; that is, into shade-bearing or light-demanding trees, and trees that occupy an intermediate position.[25] The different trees of the forests of North Carolina may be classified accordingly, as to their tolerance:

Sugar maple, flowering dogwood.
Hornbeam.
Red maple, yellow oak, beech.
Butternut, black walnut.
Witch hazel, chestnut oak, white oak.

---

[25] NISBET, Studies in forestry 54. 1894. FOLEY, JOHN, Conservative lumbering at Sewanee, Tennessee. Bureau of Forestry, Bull. 39.

White ash, umbrella tree.
Sweet gum, sycamore.
Locust, black cherry, sassafras.
Cucumber tree, chestnut.
Tulip tree.

The vegetation of such a district, therefore, is in superposed layers or stories. The different levels at which plants grow is a direct response to the environmental conditions of light and moisture. These stories or layers may be termed vegetal strata. It is evident that, as one ascends from the ground to the crown of the dominant forest trees, the moisture content of the air decreases as the light increases. On the ground in the forest, mosses, ferns, and a variety of shade-loving herbaceous plants abound on the rotting timber, or on the mold.

A relationship exists between the amount of available light and the character of the vegetation in the forest.[26] Almost all of the plants growing in the shade can adapt themselves to living in the open, exposed to the full force of the sunlight. In fact, when the timber is removed, the grass-grown or wood-grown clearings show many woodland species competing with the plants which always at first take possession of such deserted areas. Few, however, can adjust themselves to loss of light. When deprived of a large amount of light by the growth of the forest crown in density, only those species remain which are truly shade-loving. This difference of behavior explains why so few herbaceous plants are found beneath the dense shade of the hemlocks and rhododendrons. Mitchella repens,[27] Viola rotundifolia, Galax aphylla, Leptorchis liliifolia, Peramium pubescens, and Listera Smallii seem to be the more common plants tolerant of the shade of the forest. On the higher mountains, the coniferous forest acts in the same way, for when the dominant trees are removed, or the close crown broken, many herbaceous plants spring up and cover the ground.

Another noteworthy fact, which is of philosophic interest in the discussion of the light-relationship of plants, is that many species which grow beneath the shade of a deciduous forest bloom in the early spring, and complete their most important vegetative and reproductive functions before the leaves of the trees above have fully unfolded. The boreal plants, however, which remained at the north during the glacial period, are an exception to this rule, for they owe their presence in the temperate forests and sphagnum bogs to the fact that they were trapped at the close of the glacial period by the northward-moving forest trees and had to adapt themselves to the changed conditions. Those boreal plants which did not do this were exterminated by the forest plants.

---

[26] Compare MacDougal, D. T., The influence of light and darkness upon growth and development. Memoirs New York Bot. Garden **2**. 1902.

[27] The nomenclature used is that of Britton's *Manual.*

The density of the forests affords some indication of the general character of the flora. Upon the slopes of the southern Alleghenies the deciduous forest attains unsurpassed richness and variety. On the slopes of the high mountains of North Carolina and Tennessee the principal trees of the Appalachian forests attain their greatest size, and in a ride of a few hours, covering a rise in elevation of 4,000 to 6,000$^{\text{ft}}$ (1220–1,525$^{\text{m}}$), one may see growing in perfection trees of the south, such as the magnolias; trees of the middle states, such as the ashes, the oaks, the maples, the lindens; and then the birches, the pines, the mountain ashes, and the spruces, of the extreme north.[28]

Climatic and edaphic considerations.—The differences in the character of the mountain region are not determined so largely by the kind of soil, or by the amount of moisture contained in it, as are those of the Piedmont plateau and the coastal region. Within short distances in the mountains are found wide variations in elevation. A rapid lowering of the average annual temperature takes place with the increased elevation, and a proportional shortening of the growing season; increase in the rainfall and relative humidity, and a decrease in evaporation both directly from the soil and through the foliage. It is noticeable that edaphic as well as climatic factors become more xerophytic upward.[29] The effect of climatic conditions on the higher mountains is more evident than that of soils; though between certain limits of elevation changes in the character of the soil influence the kind of growth. Thus the location of Rhododendron maximum and Tsuga canadensis along the mountain streams between certain limits of elevation (climatic) is regulated purely by edaphic conditions. The growth of Castanea dentata, Quercus alba, etc., back from the streams on the hillsides in the drier ground is also edaphic. The presence, therefore, of the various tree species in the mixed forests of the southern Appalachians is dependent primarily on climatic influences, but the assembling of these species into ecologic plant associations in these mixed deciduous forests depends upon the edaphic surroundings. With the herbaceous plants of the mountain summits and with certain shrubs, their allocation to particular situations on these summits is controlled mainly by edaphic conditions. Thus Dendrium buxifolium is found growing on rock faces and rocky slopes on Grandfather Mountain, while on Roan Mountain it is found in a deep soil, rich in humus. Xerophyllum asphodelioides, Gaultheria procumbens, Paronychia argyrocoma, Geum radiatum, etc., growing on Grandfather Mountain are controlled largely in their distribution upon that peak by soil conditions. Other examples of this kind of distribution might be mentioned here, but a more detailed reference will be made to the association of species in the forests of the higher mountains, when the several regions visited by the writer are discussed from an ecologic standpoint.

---

[28] Garden and Forest 5:155, 325; *cf.* PRICE, Practical forestry in the southern Appalachians. Yearbook U. S. Dept. Agric. 1900: 354.

It is doubtful, however, if changes of soil in the larger mountain masses above 5,000$^{\text{ft}}$ (1,525$^{\text{m}}$) elevation produce any change in the kind of trees, the number of species being limited to those whose hardiness (xerophytic structure of crown or foliage and short growing season) renders them capable of withstanding the sudden changes of temperature to which they are subjected near the summits of the higher mountains.[30]

---

[29] The word "xerophyte" refers to a particular kind of plant with a definite histologic structure. The word "xerophytic" should be used also in the structural sense, although by extension it is used loosely to denote conditions that produce xerophytes.

[30] PINCHOT and ASHE, Timber trees and forests of North Carolina. N. C. Geol. Survey 1897: 208, 209.

The forests of the mountain region of North Carolina are separable, according to Pinchot and Ashe, into three belts, lying at different elevations. These are as follows: (1) the forests of the lower mountains; (2) the forests of the higher mountains; (3) the forests of the mountain summits.

Zonally (climatically) the lower slopes of the mountains and valleys between are largely occupied by extensions of the Upper Austral (Carolinian) zone, but by far the greatest part of the surface of the mountain region is covered with an Alleghanian (Transition) flora. The higher mountains maintain Canadian trees, shrubs, and herbaceous plants, while along the crest of the highest mountains of this region, usually at an altitude of $6{,}000^{\text{ft}}$ ($1{,}830^{\text{m}}$) and upward, a sparse Hudsonian flora is encountered.[31] The green alder, Alnus alnobetula (allocated by edaphic conditions), Potentilla tridentata, Arenaria groenlandica, and Trisetum subspicatum may be regarded as typical of this zone.

Ecologically the following formations may be distinguished. Primarily these formations are determined by climatic conditions, and to give them ecologic significance they are named according to the character of the vegetation that determines them. The plant associations existing as part of these formations are determined largely by light and soil-moisture (edaphic) conditions. Tentatively, the ecologic formations and associations described in the following pages are these.

1. MIXED DECIDUOUS FOREST FORMATION ($2{,}000$–$5{,}000^{\text{ft}}$, 610–$1{,}525^{\text{m}}$).

Castanea-Quercus-Acer Association.
Tsuga Association.
Rhododendron maximum Association.
Lilium Association.
Plantago-Achillea Association.
Rubus Association.
Robinia hispida Association.
Aesculus-Acer-Betula Association.
Acer-Sorbus-Viburnum Association.
Betula-Fagus Association.
Aesculus Association.

2. CONIFEROUS FOREST FORMATION ($5{,}000$–$6{,}700^{\text{ft}}$, $1{,}525$–$2{,}040^{\text{m}}$).

Sorbus-Acer-Association (poorly defined).
Polytrichum-Hypnum Association.
Sedum-Carex Association.
Veratrum Association.
Rhododendron catawbiense Association.
Carex-Poa Association.
Picea-Abies-Prunus Association.
Viburnum-Vaccinium Association.

---

[31] The student is referred to a paper by KEARNEY (Science N. S. **12**: 830, 831) for the plants that characterize these zones.

3. SUB-ALPINE DWARF TREE-SHRUB FORMATION (circa 6,000 ft, 1,830 m).

Dendrium Association.	*Geum-Paronychia Association.*

4. SUB-ALPINE TREELESS FORMATION (above 6,000 ft, 1,830 m).[32]

Rhododendron catawbiense Association.	*Dendrium Association.*
Alnus Association.	*Lycopodium-Geum Association.*
Carex-Poa Association.	*Kneiffia-Hypericum Association.*
Polytrichum Association.	

ECOLOGIC SURVEY OF THE REGION.

An ecologic survey of this region comprises a description of the flora of the north branch of the Swannanoa River and the slopes, ridges, and summits of Mount Mitchell and the mountains near it. The floras of the slopes and summit of Grandfather Mountain and of the summit and higher slopes of Roan Mountain are considered.

MIXED DECIDUOUS FOREST FORMATION.

The valley of the North Fork of the Swannanoa River is occupied by an arboreal vegetation, composed of Castanea dentata, Liriodendron tulipifera, Fagus americana, Quercus alba, Q. rubra, Magnolia acuminata, Juglans cinerea, Quercus coccinea, Q. phellos, Acer saccharum, Betula lenta (*Castanea-Acer-Quercus Association*).

These dominant trees are found somewhat back from the streams, while near the streams, with their roots in the water, or where the lower parts of their trunks may be submerged during heavy rains, grow Platanus occidentalis, Tsuga canadensis, Betula lenta (*Tsuga Association*).

In this forest, and belonging to the *Castanea-Quercus-Acer Association,* are these secondary species: Acer saccharum, Aesculus pavia, Juglans cinerea, Hamamelis virginiana, Hicoria glabra, Cornus florida, Tilia americana, Acer rubrum, Tilia heterophylla, Magnolia fraseri, Acer pennsylvanicum, and Robinia pseudacacia.

As a third lower story of the forest, the following species occur: Kalmia latifolia, Cornus florida, Cornus alternifolia, Ilex monticola, Oxydendrum arboreum, Viburnum acerifolium.

---

[32] Mount Mitchell does not show formations 3 and 4, while Roan Mountain shows all four well defined, Grandfather Mountain 3 and 4, but 4, if at all present, occupies a restricted area.

Rhododendron maximum forms a dense jungle along the borders of streams (*Rhododendron maximum Association*). Next to the secondary species mentioned above, the most important component of this forest is Rhododendron maximum, associated with Kalmia latifolia. The shade formed by these shrubs is so dense that few plants can exist in it. Saplings of Aesculus pavia, Fagus americana, and Tsuga canadensis, and a few herbs, such as Mitchella repens and Viola rotundifolia, seem to flourish, overshadowed by the laurel and rhododendron. Under the deciduous trees, where more light filters down to the forest floor, are found Podophyllum peltatum, Arisaema triphyllum, Cypripedium acaule, Cimicifuga racemosa, Sanguinaria canadensis, Euphorbia corollata, Lysimachia quadrifolia, Tradescantia montana, Galium latifolium, Pedicularis canadensis, Circaea lutetiana, Phytolacca decandra, Astilbe biternata, Mitchella repens, Scutellaria pilosa, Peramium pubescens, and such a sciaphilous[33] herb as Galax aphylla. Associated with these occur Silene virginica, Cacalia atriplicifolia, Zizia Bebbii, Lilium superbum in damp places (*Lilium Association*), with Thalictrum coriaceum. As lianes one finds Aristolochia macrophylla, Vitis aestivalis, Celastrus scandens, Smilax rotundifolia crenulata.

The dripping rocks, with damp soil pockets, support such plants as Trillium erectum, Salomonia biflora, Vagnera racemosa, Kneiffia fruticosa, Houstonia serpyllifolia, Thalictrum clavatum. In drier situations grow Caulophyllum thalictroides, Impatiens biflora, Adiantum pedatum, and Botrychium virginianum.

The clearings in the forest are tenanted by a number of introduced weeds, such as Chrysanthemum leucanthemum, Plantago lanceolata, P. Rugelii, Oxalis stricta, Trifolium repens, Carex rosea radiata, Achillea millefolium, Solanum carolinense, Arabis canadensis, Senecio aureus, and abandoned apple trees (*Plantago-Achillea Association*). Rubus strigosus forms dense bramble thickets in such areas (*Rubus Association*).

The dominant forest trees belonging to the Castanea-Quercus-Acer Association found on the slopes of Grandfather Mountain from an elevation of 3,800 to 4,500$^{\text{ft}}$ (1,150–1,370$^{\text{m}}$) are Castanea dentata, Quercus coccinea, Q. Phellos, Q. platanoides, Q. alba, Fagus americana, Magnolia acuminata, Robinia pseudacacia, Acer rubrum, Nyssa sp.; while as secondary species, usually found beneath the dominant ones, can be mentioned Prunus pennsylvanica, Rhododendron maximum, Hamamelis virginiana, and Kalmia latifolia. On this mountain the woody plants of less obvious importance, which may be considered to form a still lower story, are Pieris floribunda, Sassafras, and Robinia hispida, the last forming an almost pure growth (*Robinia hispida Association*). The herbaceous plants beneath the trees are Galax aphylla, Medeola virginiana, Diodia virginiana, Silene virginica, Pedicularis canadensis, Asclepias exaltata, Lysimachia quadrifolia, Osmunda cinnamomea, Dryopteris marginalis, Pteridium aquilinum, Uvularia puberula, Prunella vulgaris, Podophyllum peltatum, Ceanothus americanus, Monarda didyma, Chrysanthemum leucanthemum, Cerastium viscosum, Trifolium repens, and near cultivation Glechoma hederacea.

---

[33] POUND and CLEMENTS, The phytogeography of Nebraska, 166. 1900.

The forest on the northern slopes of Roan Mountain is similar to those on the Swannanoa River and Grandfather Mountain. It comprises the MIXED DECIDUOUS FORMATION with the *Castanea-Quercus-Acer Association*, as well characterized as at the places described above.

Reaching an elevation of 4,500^{ft} (1,370^{m}) on the Black Mountain Range, Picea mariana is found sparingly in the forest, as outposts of the main coniferous forest above. Associated in such places, the botanist finds as an indication of a rise in altitude, Diphylleia cymosa, Veratrum viride, Rhododendron lutea, Thalictrum clavatum, and an abundance of Houstonia serpyllifolia. As he approaches "Half Way" (5,200^{ft}, 1585^{m}) the forest of deciduous trees becomes more open by the lowering of the crown of the dominant trees (*Aesculus-Acer-Betula Association*) which are here Castanea dentata, with flat-topped crown, as an index of altitude, Quercus rubra, Q. coccinea, Aesculus pavia, Quercus alba, Acer saccharum, Betula lutea, and an occasional Picea mariana.

A somewhat different assemblage of species is found on Grandfather Mountain at an elevation above 4,500^{ft} (1,370^{m}). The dominant species are Quercus rubra, Picea mariana, Acer saccharinum, Prunus pennsylvanicum on the drier soils, and Tsuga canadensis (*Tsuga Association*) ascending along the water courses to about 4,700^{ft} (1,430^{m}). The secondary species are Acer pennsylvanicum, Sorbus americana, Viburnum alnifolium, and Acer spicatum (*Acer-Sorbus-Viburnum Association*). The herbaceous plants of this part of the mountain have more light and comprise Osmunda cinnamomea, Pteridium aquilinum, Polygonum cilinode, Houstonia serpyllifolia, Podophyllum peltatum, Lysimachia quadrifolia, Saxifraga Michauxii, Rumex acetosella, and Chrysanthemum leucanthemum. Occurring as undershrubs are Rhododendron lutea, Ribes rotundifolium, and Viburnum alnifolium.

On Roan Mountain the first indication of rise in altitude is furnished by Acer spicatum, and then by Acer pennsylvanicum, which does not descend quite so low as the mountain maple. Viburnum alnifolium occurs in great abundance when at an altitude of 4,500^{ft} (1,370^{m}) is reached. Houstonia serpyllifolia carpets the ground in many places, while in damp places Diphylleia cymosa forms masses beneath the shade of the dominant forest trees. The herbaceous plants of the forest floor at this elevation are Caulophyllum thalictroides, Actaea alba, Cicimifuga racemosa, Tiarella cordifolia, Sanguinaria canadensis, Podophyllum peltatum, Circaea alpina, Blephariglottis peramoena, Cacalia atriplicifolia, Lysias orbiculata, Chelone Lyoni, and Polystichum acrostichoides. A few straggling black spruce trees descend the mountain side and mingle with Betula lutea and B. lenta. Fagus americana, which becomes dwarfed at the edge of the coniferous belt, is associated with the birches in this tension zone (*Betula-Fagus Association*).

Aesculus octandra, which occurs at the upper edge of the tension zone, ascends the mountain into Carver's Gap, where it forms an almost pure stand of gnarled trees (*Aesculus Association*).

CONIFEROUS FOREST FORMATION.

The coniferous forest appears on the slopes of the Black Mountain Range at about 5,200^{ft} (1,585^{m}). The dominant tree of this formation is Picea mariana, associated with Abies Fraseri. Intermingled with these two coniferous trees, but nowhere making a pure growth, are Acer spicatum, Betula lutea, Aesculus flava, Sorbus americana, and Crataegus sp. (*Sorbus-Acer Association*). The trees are large and rugged, and clothed even to the topmost branches with dense coats of moss. Mosses and lichens cover the ground as with a dense mat a foot or more thick. The trunks of fallen trees are buried from sight by a living mound of green, set with flowers and ferns. The mosses and lichens collected by the writer, which form the *Polytrichum-Hypnum Association* on Potato Top and Clingmans Dome comprises the following: Polytrichum gracile, Sematophyllum delicatulum, Hypnum fertile, Hylocomium proliferum, Bazzania trilobata, Hylocomium triquetrum, Dicranum fuscescens, Hypnum reptile, Polytrichum ohioense, and Stereocaulon coralloides. Associated with these mosses are herbaceous plants and ferns, viz., Oxalis acetosella, Viola blanda, Lycopodium lucidulum, and Aspidium spinulosum intermedium. Houstonia serpyllifolia is also abundant. The rocks support in sunny places Sedum and telephioides, Carex rosea radiata, Saxifraga leucanthemifolia, Krigia montana (*Sedum-Carex Association*).

The green hellebore is found wherever the timber is more open and in extensive patches many square feet in area (*Veratrum Association*). The same association of species extends to the tops of the several mountains composing the Black Mountain Range. Acer spicatum and Sorbus americana (*Sorbus-Acer Association*) are met with in this forest belt. Many seedling spruces are providing a natural regeneration of the forest. As a secondary but important element of this belt at high elevations, is the Rhododendron catawbiense, beneath which as herbaceous associates are found Viola blanda, Trillium erectum, and Clintonia borealis (*Rhododendron catawbiense Association*).

The natural meadows on this range of mountains, surrounded by the forest of balsam and black spruce trees, are composed of such species as Carex intumescens, Juncus effusus, Carex scoparia, C. brunnescens gracilior, C. tenuis, Poa pratensis, Agrostis alba, Poa alsodes, Juncoides bulbifera (*Carex-Poa Association*).

The coniferous forest extends to the summit of Mount Mitchell 6,711^{ft} (2,045^{m}) without any indication of subalpine or alpine conditions. Wind-tossed specimens of Picea mariana, Abies Fraseri (*Picea-Abies-Prunus Association*), are seen. Huge rocks and bowlders project from the rounded dome. Menziesia pilosa, Ribes prostratum, Sorbus americana are common. Rhododendron catawbiense grows within a few feet of the Mitchell monument. The herbaceous plants of the summit are Streptopus roseus, Scirpus caespitosus, Carex brunnescens, Houstonia serpyllifolia Rumex acetosella, Trifolium repens, Asplenium filix-foemina, Saxifraga Michauxii in the crevices of the rocks, and Clintonia borealis. None of these herbs are true alpines.

Mosses are found on the trunks of trees and on the rocks, the following being noted:[34] Ulota crispa, Bryum nutans, Sematophyllum delicatulum, Hylocomium proliferum, Polytrichum gracile, Hypnum Schreberi (*Polytrichum-Hypnum Association*). The trees of the summit are Picea mariana, Abies Fraseri, Betula lutea, Prunus pennsylvanica.

The coniferous forest on Grandfather Mountain consists essentially of the same arborescent species, viz., black spruce and balsam. Associated with these are Viburnum alnifolium, Vaccinium stamineum, Acer spicatum, and Rhododendron catawbiense (*Viburnum-Vaccinium Association*). Polypodium vulgare grows in masses, associated with Galax aphylla, Oxalis acetosella, Thalictrum clavatum, Maianthemum canadensis, and Clintonia borealis.

The forest of cone bearers on the higher elevations of Roan Mountain consists of Picea mariana and Abies Fraseri as the dominant trees. Intermixed with these, but never forming pure growths, occur Aesculus octandra; Sorbus americana, Fagus americana in a dwarfed form, and as a third lower story, Ribes rotundifolium, Cornus atternifolia, and Alnus alnobetula. The forest floor, beneath the shade of the dominant trees, supports seedling conifers, Circaea alpina, Veratrum viride, Oxalis acetosella, Viola blanda, Thalictrum clavatum, Polypodium vulgare, Asplenium filix-foemina, Dryopteris spinulosa dilatata, Houstonia serpyllifolia, Tiarella cordifolia, and Clintonia borealis.

---

[34] The identification of the mosses I owe to Mrs. Elizabeth G. Britton and that of the flowering plants to Dr. John K. Small, to whom my thanks are due.

SUB-ALPINE DWARF TREE-SHRUB FORMATION.

This formation may be said to exist only at the top of Grandfather Mountain and is absent from the domes and ranges of Mount Mitchell and Roan Mountain.

The summit of the west peak of Grandfather Mountain for a limited area is bare and presents an alpine aspect, being clothed with lichens, mosses, and dense cushions of Dendrium buxifolium (*Dendrium Association*). Several of the plants remind the botanist of the New Jersey pine barrens, viz., Gaultheria procumbens, Xerophyllum asphodelioides, Pteridium aquilinum, Kalmia latifolia.

Zygadenus leimanthoides, Geum radiatum, Paronychia argyrocoma, Uvularia puberula, Clintonia borealis, Carex aestivalis, Chrosperma muscaetoxicum, and Solidago spithamea are found in exposed places (thus under edaphic conditions) (*Geum-Paronychia Association*). Abies Fraseri, Picea mariana, Clethra acuminata, Sorbus americana, Leucothoe recurva, Vaccinium pallidum, Oxycoccus erythrocarpus accompany the herbs to the mountain summit, so that this summit may be said not to be entirely treeless, otherwise the plants on it would be classed as an association of the Sub-alpine Treeless Formation.

The presence of Dendrim buxifolium, Xerophyllum asphodelioides, a pine barren species found plentifully in New Jersey, Geum radiatum, Paronychia argyrocoma, Clintonia borealis, and Chrosperma muscaetoxicum needs explanation. Paronychia argyrocoma, found on the bare mountain slopes of the White Mountains and in the Alleghenies from Virginia to Georgia and also in Maine, and Clintonia borealis are probably species of north temperate habit that were formerly more widely distributed but have been separated into distinct areas by the influence of the base-leveling operations previously described.

The geographic distribution of Xerophyllum asphodelioides and Chrosperma muscaetoxicum is probably to be accounted for in the same manner as the distribution of the austro-riparian species that occur in the southern Appalachians. It is hardly likely that the seeds of these plants were carried to the summit of the few isolated peaks by birds, because one would expect to find them in intermediate situations. Another explanation must be appealed to. It is probably found in the uplift at the close of the Cretaceous period, followed by the subsequent base-leveling operations. While the eastern United States, including that part of New Jersey along the Delaware River, was an almost featureless peneplain during the close of the Cretaceous, it is conceivable that the plants above mentioned had a more general distribution, and that when the uplift of the Appalachian system occurred and the formation of the Tertiary coastal plain was well under way, these plants, then widely distributed, were subjected to the influences of the processes of gradation. The wearing away of the soil from the mountains, the formation of valleys, and the oscillations of the coast line led to a process of extermination, and many plants succumbed in those regions to the geologic changes. The survivors of many widely distributed groups of plants are found, therefore, in those places that resisted the action of the destructive forces, such as the present summits of high mountains, or are in regions not subjected to the oscillations in level of the coastal plain. This supposition is supported by the suggestion of Cowles, that in all probability these plants survive under such conditions because the summits of these mountains and the sandy coastal plain are in about the same stages of their life histories. It seems to the writer, that the similarity of the situations, which are in the same edaphic stage of their life histories, consists in this.[35] In the dry places, especially the insolated slopes of the high mountains, the humus is sour or "raw;" in fact, the dense tangle which roots often form in such situations is well known for its tendency to produce sourness by hindering aeration. Similar sour humus is found in the wet swampy forests. Sour humus makes it more difficult for the roots to absorb moisture, and consequently it becomes necessary for the plant to reduce transpiration. The lack of oxygen and assimilable forms of nitrogen in such soils still further induces a weakening of physiologic activity. It appears clear, therefore, that the number and importance of xerophilous conditions increases in inverse proportion to the presence of fresh well-aerated humus. Does not this circumstance seem to imply that there must be some causal connection between the quality of the humus and the occurrence of xerophytic characters? The presence of such plants as Xerophyllum asphodelioides, Paronychia argyrocoma, Chrosperma muscaetoxicum on the summit of Grandfather Mountain, and Dendrium on both Grandfather and Roan Mountains seems thus to be explained.

---

[35] This thought was suggested by a reading of a paper by ERNEST BRUNCKEN, Contributions to the ecology of the genus Viola. Bull. Wis. Nat. Hist. Soc. **2**: 27.

SUB-ALPINE TREELESS FORMATION.

This formation is encountered typically on Roan Mountain and on other mountain summits in the southern Appalachians that are grassy balds. The "balds" are in the main grassy meadows, but the rounded domes show extensive areas covered by the Rhododendron catawbiense (*R. catawbiense Association*), either pure, or associated with Alnus alnobetula (*Alnus Association*). The alder covers an adjoining dome of the Roan Mountain Range, the Elkhorn, with a pure and impenetrable growth three to four feet high. The extent of the rhododendron thickets, for which the mountains is famous, cannot easily be estimated. The bushes may be either rounded, like a hay stack, or they may be spreading at the top.[36] The character of the plants, as indicated by the general habit and nature of the leaves, depends upon whether the plants are exposed to the cold winds of summer, the intense sunlight, the icy blasts of winter, or whether they are more or less sheltered by the slope of the ground, or by growing beneath the protection of the spruces and silver firs.

The summit of Roan Mountain is in the form of a saddle several miles long, being formed of two elevations of about equal height, the culminating peak being 6,313$^{\text{ft}}$ (1,924$^{\text{m}}$) in altitude. The component vegetation of the grassy meadows, or "balds" consists of Trifolium repens, Rumex acetosella, Potentilla canadensis, Poa compressa, Veronica officinalis, Houstonia serpyllifolia, Carex tenuis, Deschampsia flexuosa, Luzula campestris, and Phleum pratense (*Carex-Poa Association*). Polytrichum commune forms patches, especially about old stumps (*Polytrichum Association*).

---

[36] *Cf.* CANNON, W. A., Field notes on *Rhododendron Catawbiense.* Torreya **2**: 161. 1902.

The raised cushions of soil found here are covered by various mosses, or by Dendrium buxifolium[37] (*Dendrium Association*). In or along the dry stony wash-ways, one finds Saxifraga leucanthemifolia, Potentilla tridentata, and Houstonia purpurea.

The immediate summit of Roan Mountain is characterized by the presence of Geum radiatum, Lycopodium selago (*Lycopodium-Geum Association*), Menziesia pilosa, Houstonia purpurea, Lycopodium lucidulum, Ribes rotundifolium, Dendrium buxifolium. Alnus alnobetula clings to the north slopes, here forming a pure growth on the steeper inclines (*Alnus Association*), with Sorbus americana below it, but associated with Rhododendron catawbiense on the upper slopes of the dome.

Crossing Carvers Gap, where Aesculus octandra grows (*Aesculus Association*), a rocky outcrop is found on the slope of Little Roan Mountain where the writer collected Rhododendron lutea, Kneiffia fruticosa, Geum geniculatum, Arisaema quinatum and Hypericum graveolens (*Kneiffia-Hypericum Association*). Alder Bald or Elkhorn, as it is called, is reached from Little Roan Mountain by crossing a smaller wind gap. The slopes of this knob are covered by acres of Alnus alnobetula (*Alnus Association*), while the stony places are favorable for the growth of Heuchera villosa, Krigia montana, Cerastium vulgatum, and two alpine species, Potentilla tridentata and Alsine groenlandica. The latter herb assumes the cespitose character in exposed situations.

In conclusion, it is advisable to state that the dwarfing of the trees and their absence on the "balds" is explicable by the action of winter storms which beat upon these summits. Wherever the topography is such as to permit the full force of the ice storm, there tree vegetation is scanty or altogether wanting, and its place is taken by grassy stretches, or by thickets of alder and rhododendron, plants which are adapted to withstand ice storms.[38]

---

[37] *Cf.* SMALL, J. K., Flora of western North Carolina and contiguous territory. Mem. Torr. Bot. Club 3.

[38] HARSHBERGER, J. W., Thermotropic movements in the leaves of *Rhododendron maximum* L. Proc. Acad. Nat. Sci. Philadelphia 1899: 219.

Mrs. Edson[39] describes the action of a winter storm upon the vegetation. The factor in the production of the frost forms which weigh down the limbs of trees and snap them off is the frozen vapor of the wind and rain. The lower the temperature, the denser the cloud becomes; the velocity of the wind and the exposure determine the growth of the frost forms. Hence the absence of trees is due to the effect of the ice and snow of winter. This conclusion is strengthened by a study of a recent ice storm at Philadelphia,[40] as it damaged large trees that had withstood the storms of centuries.

In lieu of illustrations to accompany this article, the reader is referred to a magnificent volume issued by the United States Government,[41] where maps and photographs descriptive of the proposed Appalachian National Park are given.

UNIVERSITY OF PENNSYLVANIA.

---

[39] EDSON, Mrs. HELEN R., Frost forms on Roan Mountain. Pop. Sci. Mo. **45**:30. 1894.

[40] Forest Leaves **8**:168. 1902; also CHAPMAN, Forestry and Irrigation **8**:130. 1902; Experiment Station Record **13**:1053.

[41] See Message from the President of the United States transmitting a Report of the Secretary of Agriculture in relation to the forests, rivers, and mountains of the southern Appalachian region. Senate Document 84:210. Washington. 1902.